RESPONSE OF ELK TO EXXON'S FIELD DEVELOPMENT IN THE RILEY RIDGE AREA OF WESTERN WYOMING

1979 - 1990

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ABSTRACT

Responses of wintering and calving elk (Cervus elaphus) to the development of Exxon's natural gas wellfield on public lands near La Barge, WY were measured by comparing changes in distribution patterns and numbers sighted between pre-construction, construction, post-construction, and production periods. Elk numbers and locations were determined from counts conducted from aircraft between 1979 and 1990. The statistical significance of differences in numbers of elk sighted in individual sections of land between the four periods were tested with standard chi-square procedures. On both winter and calving ranges elk moved out of or away from areas where construction activities were occurring and returned when these intensive activities ceased. Elk trend counts and hunter harvest data indicated that construction activities did not cause a reduction of elk numbers in the herd unit. The study exemplifies the critical value of thorough long-term planning and execution of baseline wildlife research, the need for consistent long-term data collection, and the continuing cooperation between industry and resource management agencies in siting oil and gas development to minimize impacts to wildlife.

INTRODUCTION AND HISTORY

This study was conducted in the Wyoming Range in southwest Wyoming in an area known as the Overthrust Belt (Figure 1). Mountain ranges in this area provide diverse wildlife habitats, including year-round habitats for large numbers of Rocky Mountain elk. Exploration for hydrocarbon reserves occurred in the 1960s, and a large natural gas field was discovered on the east flank of the Wyoming Range. This gas reserve, known as the Riley Ridge Gas Field was found at depths below 14,000 feet and contained methane, carbon dioxide, and hydrogen sulfide. This field was not initially developed because of the high cost of construction and relatively poor quality of gas. However, the high energy prices of the 1970s and early 1980s made it economically feasible to explore for and develop this and other natural gas fields in the Overthrust Belt.

Between 1978 and 1982 exploratory wells that defined the extent of the Riley Ridge field were drilled and, in 1982, four companies announced plans to develop their leases within this field. An Environmental Impact Statement (USDI - BLM and USDA - FS 1984a) and Record of Decision (USDI - BLM and USDA - FS 1984b) identified issues and general mitigation measures and served as a basis for planning field development. Site-specific mitigation measures were developed for each well, road, and facility constructed. Only Exxon Company U. S. A. (Exxon) proceeded with field development. Exxon received necessary permits from the state of Wyoming through the Industrial Siting Council, and additional mitigation was identified. As a part of this mitigation, Exxon provided funding to the Wyoming Game and Fish Department (WGFD) to monitor response of elk to construction activities. Exxon's siting permit included drilling 18 wells and constructing pipeline and manifold structures, dehydration facilities and a gas treatment plant. Exxon's LaBarge Project was developed between 1984 and 1986 over 40,500 acres, overlapping summer, winter, crucial winter, and calving ranges of elk (Figure 2).

Based on various studies of elk response to logging (Black et al. 1976, Hershey and Leege 1976, Lyon 1976), roads (Lyon 1979, Ward 1976, Rost and Bailey 1979), and seismic exploration (Gillin 1989), WGFD was concerned that wells drilled on crucial winter ranges and calving areas could have a negative impact on elk. In these studies, elk moved at least 0.5 miles from activities or placed a physiographic barrier between themselves and the disturbance. Most of these studies were on summer ranges. Elk response to activities on winter range is less well documented. Hayden-Wing (1979) found that snow depth was second only to human disturbance in controlling elk use of winter range in southeastern Idaho. Sweeney and Sweeney (1984) found that elk preferred areas where snow was <16 inches deep but would foiage in areas where snow was up to 28 inches deep. Knight (1980) found that elk habituated to drilling in northern Michigan where >90% of the study area was forested and provided abundant hiding and security cover. Ward (1976) found that elk habituated to constantly moving traffic along Interstate Highway 80.

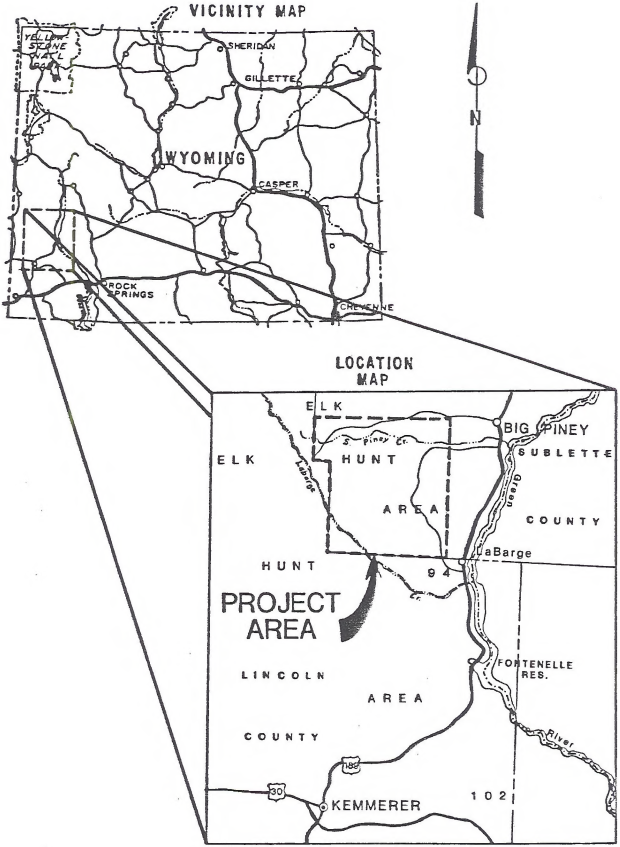

Figure 1. Location of the Riley Ridge gas field on the east side of the Wyoming Range in southwest Wyoming.

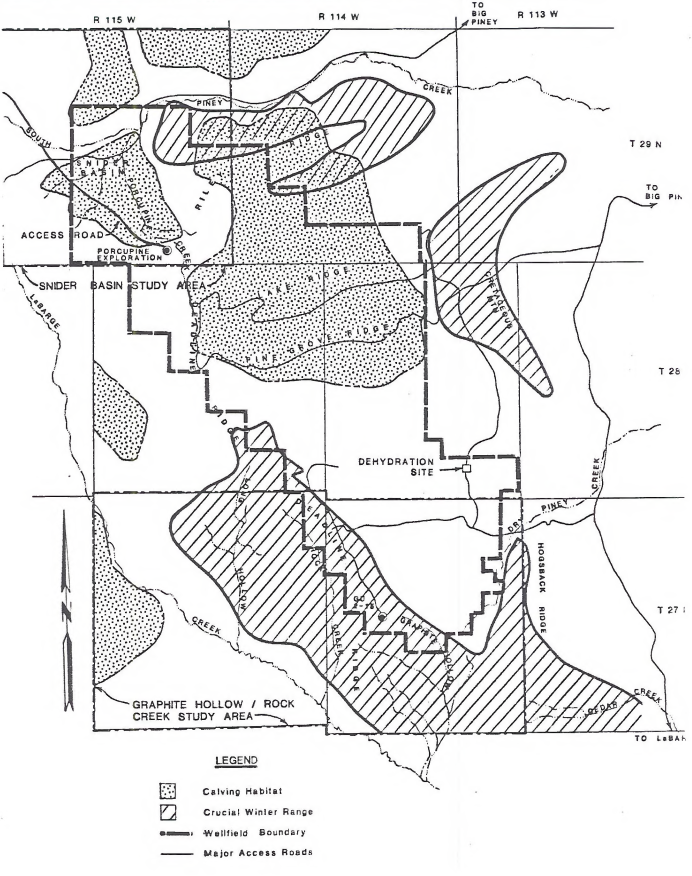

Figure 2. Locations of wells studied in relation to elk winter and calving ranges within the wellfield of the LaBarge Project, Wyoming.

In this report, elk distribution from 1979 to 1990 was analyzed on two segments of the wellfield: Snider Basin calving area and Graphite Hollow/Rock Creek (GH/RC) winter range. Distributions of elk during pre-construction, construction, post-construction, and production periods were compared, and the effectiveness of mitigation measures implemented was evaluated. Elk responses were contrasted to responses from earlier, unrelated oil and gas development on adjacent elk winter ranges where planning and coordination did not occur. Because insufficient data were available for the Riley Ridge and Pine Grove winter ranges, and Lake Ridge calving area, no attempt was made to analyze differences in elk distribution on these ranges. For the same reason, no analysis of the cumulative effects of the entire project on elk distribution or numbers within the entire wellfield was made.

STUDY AREA

Graphite Hollow/Rock Creek Winter Range

Habitat Description

The GH/RC winter range (Figure 2) is administered by the BLM and includes Graphite Hollow, Long Hollow, Rock Creek, and portions of Cedar Creek and Dry Piney Creek drainages. This winter range is located on the southern end of Deadline Ridge and varies in elevation from 7,260 to 9,570 feet. Extensive oil and gas development occurred on Cedar Creek and Dry Creek drainages during the 1950s, 60s, and 70s. Foraging areas on the winter range are limited mostly to ridges or slopes with southern or southwestern aspects where wind and solar insolation reduce snow depths. Graphite Hollow contains approximately 16,000 acres of crucial winter range dominated by sagebrush (Artemisia spp.) or mixed grass stands with a few isolated stands of aspen (Populus tremuloides). Conifer cover, consisting of lodgepole pine (Pinus contorta), limber pine (Pinus flexilis), and Douglas fir (Pseudotsuga menziesii), is limited to the head of Graphite Hollow. Rock Creek provides both forage and cover on approximately 8,000 of crucial winter range that is dominated by mixed grasses interspersed with stands of aspen, mixed conifer, and curlleaf mountain mahogany (Cercocarpus ledifolius). Areas of drifted and deep snow are found on northern and western exposures within this winter range. The conifer cover, consisting mostly of lodgepole pine (Pinus contorta), is limited to the higher elevations and northerly aspects at lower elevations.

Drilling/Construction Scenario

Exxon filed an Application for Permit to Drill (APD) a well in Graphite Hollow in 1984, one year earlier than originally planned. The proposed well site was on a ridge about 0.5 miles from the nearest conifer cover. Negotiations were held among BLM, Exxon, and WGFD representatives over this well, and mitigation measures were identified. The well was moved into conifer cover, and Exxon used directional drilling techniques to reach the drilling target. The drill pad was constructed in summer 1984, and drilling started that fall (Figure 3). The access road, located in conifers, was not visible from foraging areas on the winter range and approached the well from the north (Figure 4). Foraging areas within the winter range were closed to all motorized vehicles, including snow machines, by the BLM. Drilling was completed on 19 December 1985, and all activities at the well site ended after mid-January 1986. Pipelines were constructed in summer 1986, and the well was placed into service that summer. Since then the well has been checked at least twice weekly via over-snow vehicles, and by remote sensing. Although the well location was separated from the foraging areas on the winter range by stands of aspen and lodgepole pine trees about 100 feet in depth, the drilling rig was visible from most locations in Graphite Hollow and noise associated with the drilling activity was audible throughout the winter range. When the well location was reclaimed in summer 1986, lodgepole pines 10-

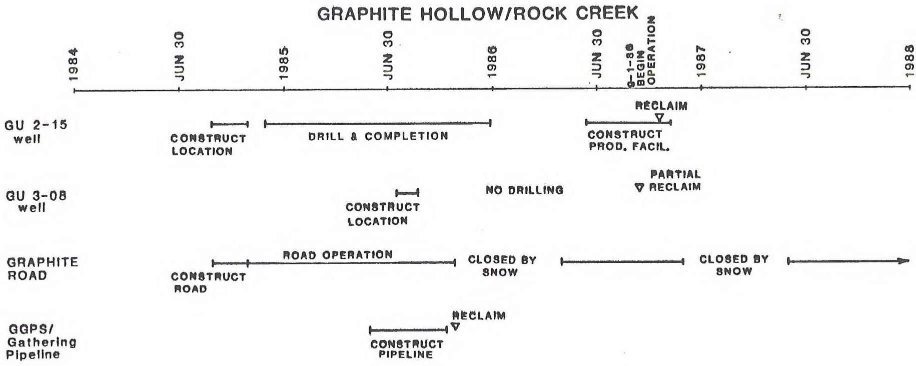

Figure 3. Schedule of drilling and construction events on the Graphite Hollow/Rock Creek Winter Range and Calving Area (1980-1988).

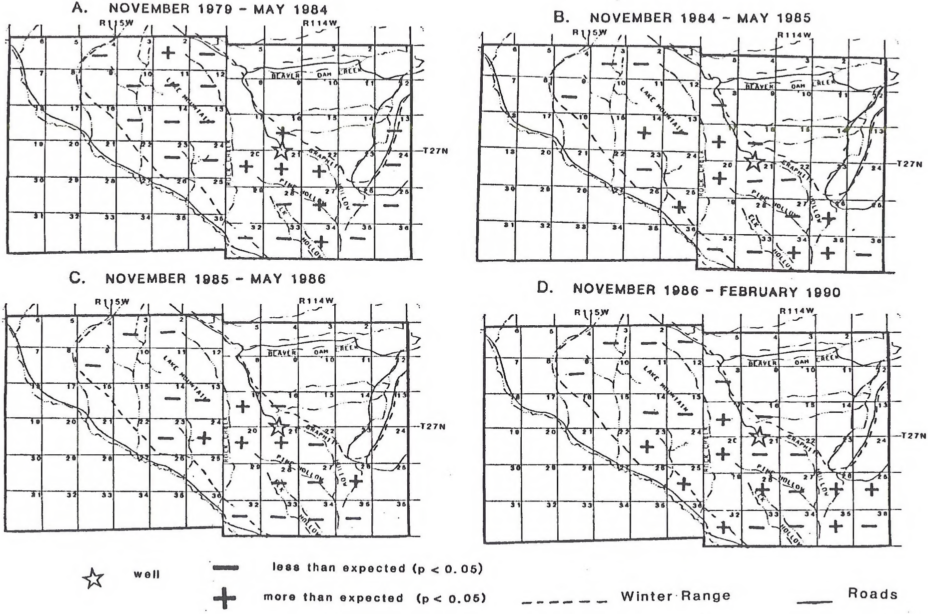

Figure 4. Comparisons of distribution of elk, by sections, on Graphite Hollow/Rock Creek winter range, Wyoming, during pre-construction (A), construction (B), post-construction (C), and production (D) using X^2 analysis. During the pre-construction period, expected values were based on assumed uniform distribution of elk among sections. During the other 3 periods, expected values for X^2 were based on observed distribution in pre-construction period.

17 feet tall were planted between the well head and foraging areas to provide an additional visual barrier to the winter range.

Snider Basin Calving Area

The calving area in Snider Basin is within the Bridger-Teton National Forest and consists of a large basin drained by four perennial streams that flow into South Piney Creek (Figure 2). The basin is approximately 6,300 acres in size and is surrounded by Riley Ridge on the east, Deadline Ridge on the south, Packsaddle Ridge to the west, and Darby Mountain on the north (Figure 5). Elevation within the basin varies between 8,000 to 8,300 feet. The maximum elevation of the surrounding rim is 9,828 feet and occurs on the northern end of Riley Ridge. Vegetation within the basin consists of wet meadows dominated by Carex spp., Potentilla fruiticosa, willows (Salex spp.), and sagebrush interspersed with mixed conifer stands dominated by lodgepole pine, Engelman spruce (Picea engelmannii), and subalpine fir (Abies lasiocarpa). A mosaic of mixed conifers, interspersed with aspen, sagebrush, and wet meadows, occupies the slopes east of the basin. The other slopes are dominated by mature to over-mature stands of mixed conifers and early successional lodgepole pine in clearcuts. A more detailed description of Snider Basin is contained in Johnson and Lockman (1980).

When Exxon filed an APD, in 1978, to drill an exploratory well in Snider Basin, concerns were raised about the response of elk during calving to activities associated with drilling this well. Field inspections of the site were made, along with discussions in meetings involving Exxon, Forest Service (FS), and WGFD representatives. As a result of this planning, the well and access road were sited within conifer stands to reduce visibility and buffer noise levels. The road was closed to all public traffic during and after construction. The FS used the road occasionally for administrative use. Drilling was to be completed by May 1, prior to the elk calving season.

Drilling the well to the depth needed (>14,000 feet) was more difficult than expected, and Exxon was unable to meet the calving season deadline. When Exxon was granted permission to extend drilling beyond the May 1 cutoff date it provided an opportunity to evaluate the response of elk during calving to construction activity (Johnson and Lockman 1980). During 1984, two other wells were drilled (Figure 6) during the calving season in Snider Basin (Figure 5-C) and provided a second opportunity to evaluate elk responses. The second well sites and access roads were also placed in locations where they were screened from the calving range by conifer stands. Roads were closed after construction was complete. None of the wells in Snider Basin have been placed into production, consequently, the conclusions drawn in this report about calving areas refer only to responses of elk to drilling activities.

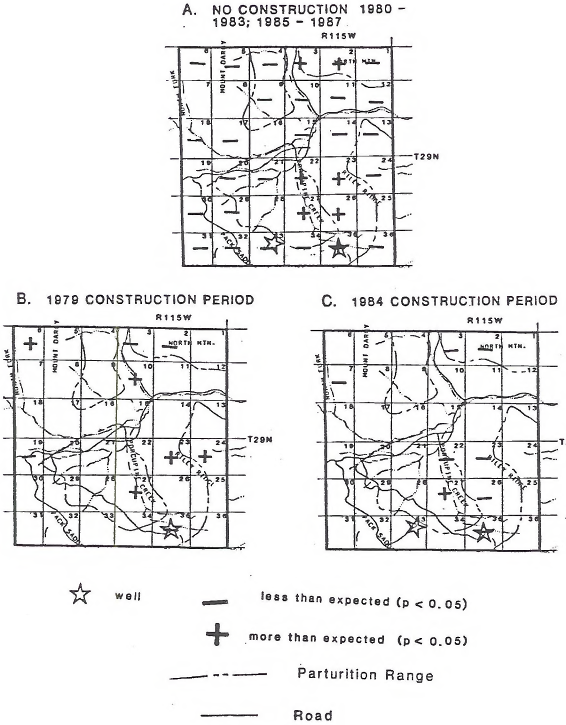

Figure 5. Comparisons of distribution of elk, by section, on Snider Basin calving area, Wyoming, during no-construction periods (A) and 2 construction periods (B and C) using X^2 tests. During the no-construction period, expected values were based on assumed uniform distribution of elk among sections. During the 2 other periods, expected values for X^2 were based on observed distribution in the no-construction period.

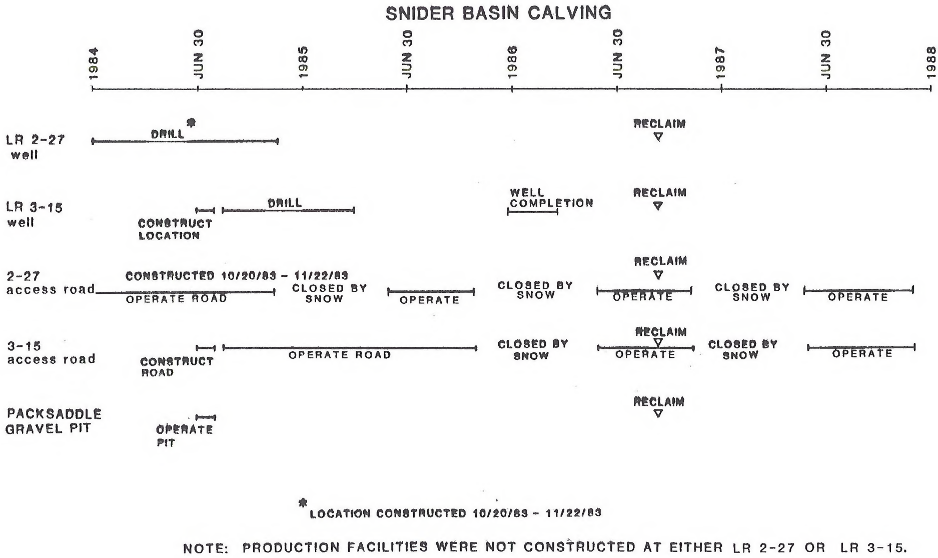

Figure 6. Schedule of drilling and construction events on the Snider Basin Calving Area (1980-1988).

Piney Elk Herd

Both study areas were in elk Hunt Area 94, and the GH/RC area abuts Hunt Area 102 on LaBarge Creek (Figure 1). Hunt Areas 94 and 92 have 207 mi^2 of occupied elk habitat and comprise the Piney Elk Herd. Elk are managed by herd units by the WGFD with management objectives for population, harvest, number of hunters, recreation days, and days hunted per animal harvested. Five feedgrounds are located in this herd, and the WGFD has an objective for the number of elk at each feedground. Feedgrounds were established to minimized elk damage to stored crops. Prior to 1986, the population objective for this herd was about 1,700 elk on feedgrounds and 450 elk on native winter range. In 1986, the feedground objectives were changed, increasing the objective for this herd to 2,424 elk. The closest feedground is about 17 miles north of the GH/RC winter range, the largest native winter range within the herd unit. Hunt Area 102, part of the West Green River Elk Herd, contains no feedgrounds.

METHODS

Elk response to drilling and construction activities was assessed by monitoring changes in numbers and distribution patterns as determined from aerial survey flights. Distribution and density patterns, as indicated from the analysis of historical data, provided a base from which to measure deviations caused by the drilling and construction activities. Movements of several elk which were captured and radio-collared on the Graphite Hollow/ Rock Creek winter range contributed some information on response behavior.

Elk Numbers. Numbers of elk on the GH/RC winter range were obtained from November 16 - May 14 each winter. During the pre-construction period (April 1979 - May 1994), 10 surveys were flown, and 1,728 elk were observed. During the construction period (November 1984 - May 1985), nine flights were made, and 1,351 elk were counted. Six surveys were conducted during the November 1985 - May 1986 post-construction period, and 844 elk were counted. Nine flights were made during the production period, November 1986 - February 1990, and 1,742 elk were counted (Tables 1 and 2).

The number of elk counted on winter trend counts and the mean number counted on all flights among the four periods were compared using ANOVA. Data from flights where less than 100 elk were counted were deleted, because they generally consisted of late winter/spring counts after most elk had left winter ranges.

Aerial surveys were conducted in the Snider Basin area at least once each year during the calving period (May 16 - July 15), usually during late May or early June from 1979 - 1988. Elk were observed on 27 days during the 1980 calving season and on 24 other days from 1979 - 1988. A large amount of data was collected during 1979 and 1980 (Johnson and Lockman 1980). During the construction periods (1979 and 1984), 229 elk were counted; 917 were counted during the first no-construction period (1980 - 1983). A total of 56 was counted during the second no-construction period (1985 - 1988).

Most flights were made in fixed wing aircraft, except one winter-trend count made each year from 1981 - 1990 in a helicopter. All winter ranges were surveyed on trend counts.

Elk Distribution. Observations made during aerial surveys were pooled with all other observations of elk distribution stored in the WGFD's computerized Wildlife Observation System (WOS). These pooled data were used to analyze changes in elk distribution. No useable information existed prior to 1979 in the WOS for the study area (i.e., elk locations reported by legal description).

Chi-square goodness of fit (Zar 1974) was used to test the hypothesis that elk were uniformly distributed on winter range in the pre-construction period and to identify areas where elk concentrated, as well as areas that were unused or lightly used. Expected distribution was a uniform distribution. The significance of changes in distribution during

Table 1. Snow depths in Snider Basin and number of elk counted on aerial surveys of the Graphite Hollow/Rock Creek winter range, Wyoming, April 1979 - February 1990.

Period	Date		Snow depth Inches	Snow depth % of 25[b] yr mean	Elk counted
Pre-construction					
	27 Apr	1979	31	86	153
	27 Apr	1980	34	94	142
	4 May	1980	29	81	70
	13 Mar	1981[a]	27	54	138
	16 Jan	1982	58	132	159
	18 Feb	1982[a]	59	118	282
	13 Jan	1983[a]	33	75	161
	15 Apr	1983	43	86	122
	5 Jan	1984[a]	40	91	209
	4 Apr	1984	46	90	248
Construction					
	3 Jan	1985	37	84	163
	10 Jan	1985[a]	37	84	203
	16 Feb	1985	42	96	80
	28 Feb	1985	49	98	171
	5 Mar	1985	49	98	226
	20 Mar	1985	50	98	124
	6 Apr	1985	47	92	140
	24 Apr	1985	28	78	153
	1 May	1985	20	56	91
Post-construction					
	26 Dec	1985	43	98	175
	4 Jan	1986[a]	43	98	197
	29 Jan	1986	43	98	114
	4 Mar	1986	75	150	162
	17 Mar	1986	56	110	117
	1 May	1986	50	139	80
Production					
	17 Feb	1987[a]	43	86	168
	28 Jan	1988	36	82	203
	20 Feb	1988[a]	38	76	249
	10 May	1988	18	50	14
	18 Jan	1989	36	82	173
	9 Feb	1989[a]	38	86	207
	13 Jan	1990	27	61	52
	31 Jan	1990[a]	42	95	186
	23 Feb	1990	41	82	135

[a] Trend count

[b] 1961 - 1985 mean for February 1 = 44"; March 1 = 50"; April 1 = 51"; May 1 = 36".

Table 2. Total numbers of elk counted on sections of land within crucial elk winter range on Graphite Hollow/Rock Creek winter range, Wyoming, April 1979 - February 1990 during ground and aerial surveys.

	Period							
Section	Pre-construction		Construction		Post-construction		Production	
	No. (%)	Prob.[c]	No. (%)	Prob.	No. (%)	Prob.	No. (%)	Prob.
T27N, R114W								
8	53 (3.1)[a]	0.105-	25 (1.9)	0.012-	29 (3.4)	0.62	0 (0.0)	<0.001-
16	88 (5.1)	0.008+	0 (0.0)	<0.001-	0 (0.0)	<0.001-	22 (1.3)	<0.001-
17	55 (3.2)	0.17 -	451 (33.4)	<0.001+	105 (12.4)	<0.001+	379 (21.8)	<0.001+
20	134 (7.8)	<0.001+	245 (18.1)	<0.001+	333 (39.4)	<0.001+	246 (14.1)	<0.001+
21	117 (6.8)	<0.001+	70 (5.2)	0.023-	103 (12.2)	<0.001+	88 (5.1)	0.004-
22	307 (17.8)	<0.001+	36 (2.7)	<0.001-	92 (10.9)	<0.001-	52 (3.0)	<0.001-
25	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	151 (8.7)	NA+
26	43 (2.5)	0.004-	96 (7.1)	<0.001+	98 (11.6)	<0.001+	131 (7.5)	<0.001+
27	217 (12.6)	<0.001+	47 (3.5)	<0.001-	0 (0.0)	<0.001-	111 (6.4)	<0.001-
28	35 (2.0)	<0.001-	24 (1.8)	0.578	0 (0.0)	<0.001-	84 (4.8)	<0.001+
29	56 (3.2)	0.21 -	51 (3.8)	0.301	21 (2.5)	0.00[b]	41 (2.8)	0.312-
32	9 (0.5)	<0.001-	0 (0.0)	0.013-	0 (0.0)	0.006-	23 (1.3)	0.001+
33	17 (1.0)	<0.001-	0 (0.0)	<0.001-	0 (0.0)	<0.001-	0 (0.0)	0.001-
34	95 (5.5)	<0.001+	174 (12.9)	<0.001+	0 (0.0)	<0.001-	0 (0.0)	0.001-
35	22 (1.3)	<0.001-	28 (2.1)	0.012+	0 (0.0)	<0.001-	186 (10.7)	0.001+
36	55 (3.2)	0.17 +	0 (0.0)	<0.001-	25 (3.0)	0.070	0 (0.0)	0.001-
T27N, R115W								
1	4 (0.2)	<0.001-	0 (0.0)	0.136-	0 (0.0)	0.45	0 (0.0)	0.024-
2	166 (9.6)	<0.001+	0 (0.0)	<0.001-	0 (0.0)	<0.001-	2 (0.1)	<0.001-
3	74 (4.3)	0.377	0 (0.0)	<0.001-	0 (0.0)	<0.001-	4 (0.2)	<0.001-
5	18 (1.0)	<0.001-	0 (0.0)	<0.001-	0 (0.0)	0.005-	0 (0.0)	<0.001-
8	4 (0.2)	<0.001-	0 (0.0)	0.136-	0 (0.0)	0.45	1 (0.1)	0.078-
9	67 (3.9)	0.00[b]	0 (0.0)	<0.001-	0 (0.0)	<0.001-	0 (0.0)	<0.001-
10	3 (0.2)	<0.001-	0 (0.0)	0.227-	0 (0.0)	0.41	0 (0.0)	0.426-
11	0 (0.0)	0.00[b]	3 (0.2)	NA	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]
12	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	3 (0.2)	NA+
13	28 (1.6)	<0.001-	0 (0.0)	<0.001-	0 (0.0)	0.013-	4 (0.2)	<0.001-
14	17 (1.0)	<0.001-	71 (5.3)	<0.001+	4 (0.5)	0.007-	0 (0.0)	<0.001-
15	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	2 (0.1)	NA
16	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	12 (0.7)	NA+
23	28 (1.6)	<0.001-	0 (0.0)	<0.001-	1 (0.1)	<0.001-	40 (2.3)	0.032+
24	16 (0.9)	<0.001-	10 (0.7)	0.549	25 (3.0)	<0.001+	10 (0.6)	0.008
25	0 (0.0)	0.00[b]	20 (1.4)	NA+	8 (0.9)	NA+	149 (8.6)	NA+
26	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]
27	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	0 (0.0)	0.00[b]	1 (0.1)	NA
Totals	1728		1351		844		1742	

[a] Numbers in parentheses ( ) represent % of total count for period.
[b] Expected value = 0; could not calculate X^2 value.
[c] Probability of a greater X^2 value.
\+ Observed number of elk significantly greater than expected ($p<0.05$)
\- Observed number of elk significantly lower than expected ($p<0.05$)

construction, post-construction and production were also determined with chi-square goodness of fit tests. Observed distributions in the pre-construction period served as expected values. A separate chi-square test was preformed for each section. The same tests were performed on calving range, only observations from the no-construction period served as expected values when analyzing distribution observed during the two construction periods.

During pre-construction periods, all elk observed in surveys were combined for each legal section occupied by elk on each calving and winter range. The chi-square goodness of fit analysis was used to test the hypothesis that all elk seen during pre- and no- construction periods were distributed uniformly throughout their occupied range during any given period. According to this hypothesis, a uniform distribution of elk would be indicated by the same number of animals on each legal section of occupied range. For example, if 900 elk were seen occupying 25 sections of winter range, then 36 elk would be expected on each section if they were uniformly distributed. The significance of deviations between observed and expected elk occurrence on each section occupied by elk during pre- and no-construction periods was computed by the following:

$$\text{Chi-Square} = \frac{(\ O1 - E1 \quad - 0.5)^2}{E1} + \frac{(\ O2 - E2 \quad - 0.5)^2}{E2}$$

Where:

O1 = Total number of elk found within a given section of range during pre- or no-construction periods.

E1 = The expected number of elk on each occupied section if elk were uniformly distributed (total elk observed/total number of occupied sections).

0.5 = Yates correction for continuity (Zar 1974) to avoid rejecting the null hypothesis when it is true.

O2 = Total observed number of elk on all occupied sections except the one being analyzed.

E2 = Total expected number of elk on all occupied sections except the one being analyzed.

By comparing computed chi-square values for each legal section occupied by elk to table chi-square values having one degree of freedom (1 d.f.), the hypothesis that observed and expected occurrence of elk on each occupied section were the same could be rejected with a known probability of being correct. In these analyses, probabilities of 95% ($p < 0.05$) were used to identify legal sections on calving or winter ranges where elk occurrence

was considered to be significantly more than, less than, or the same as expected during pre- and no-construction periods. Such an analysis indicates the relative importance to elk of each legal section on calving or winter range.

Observations of elk made during pre- and no-construction periods were used to evaluate elk distributions on calving and winter ranges during construction post-construction, and production periods. In these analyses, the tested hypothesis was that elk distributions during construction, post-construction, and production periods did not differ significantly ($p < 0.05$) from their expected distribution derived from observations made during pre- or no-construction periods. Here, the expected number of elk on each section during construction, post-construction, or production (E*1) is computed as:

$$E^*1 = (T^* / T) \cdot O1$$

Where:

- O1 = Observed number of elk on that section during pre- or no-construction periods.
- T = Total number of elk on all occupied sections during the pre- or no-construction periods.
- T* = Total number of elk on all occupied sections during the construction, post-construction, or production periods.

Chi-square values for each legal section occupied by elk during construction and post-construction are calculated by the following:

$$\text{Chi-Square} = \frac{(\ O^*1 - E^*1\ - 0.5)^2}{E^*1} + \frac{(\ O^*2 - E^*2\ - 0.5)^2}{E^*2}$$

Where observed and expected values are as above but the asterisk denotes values for construction, post-construction, and production periods. When computed chi-square values exceeded table values for 1 d.f. and $p < 0.05$, it was concluded that the number of elk on a given section during construction, post-construction, or production deviated significantly from what was expected during pre- or no-construction periods. In this way, changes in elk distribution on each legal section of calving or winter range during periods of gas field development could be evaluated.

Radio Monitoring. In an attempt to document movements within and fidelity to the GH/RC winter range between years, elk trapping and radio-collaring was conducted during the winter of 1985-1986. Additional trapping and marking of elk was performed on the Finnegan Feedground between February 1982 and March 1984 where a total of 116 elk

were captured and ear-tagged. Of these, 54 were also neck-banded and 21 were fitted with radio collars.

Four hay-baited clover-leaf traps were placed in the Rock Creek drainage during the fall of 1985 and trapping was initiated in January 1986. Efforts were made to minimize human disturbance at the trap sites. Traps were set for 3-5 days, then closed for 5-7 days to allow elk undisturbed access to portions of the winter range near the trap sites. Trapping was not conducted in the Graphite Hollow drainage to avoid harassing elk away from the drill site. Trap site visits were minimized by using radio transmitters, affixed to the traps, which emitted signals when traps were closed. Four traps were operated for 22 nights for a total of 88 trap nights.

<u>Snow Depths</u>. Measurements of snow depth were obtained from a USDA Soil Conservation Service (SCS) snow survey site in Snider Basin at 8,060 feet, 13 miles north of the winter range. Snow depths were extrapolated for flights on days when the SCS did not measure snow depths between February 1 and May 14. Snow depths from February 1 were used for flights conducted in January. Annual snowpack was the mean of the February 1, March 1, and April 1 snow depths.

A linear regression and correlation of elk numbers counted (dependent variable) with snow depth were determined for the four periods. The hypothesis tested was that elk numbers counted were not correlated with snow depth during the four periods.

<u>Elk Harvest</u>. Harvest statistics were estimated annually by a random mail survey of elk hunters, conducted by the University of Wyoming. Harvest was summarized by hunt area.

RESULTS

Snider Basin Calving Area

Significant differences in elk distribution patterns between construction and no-construction periods were observed and showed that elk moved away from construction activities during the 1979 and 1984 calving seasons and, following the completion of drilling, began to return the next year (Figure 5). During the no-construction periods, elk were concentrated in eight sections ($p < 0.05$). Five were in the south end of Snider Basin, and three were in north end of the township (Figure 5-A). During the 1979 construction period, elk used the section where the well was drilled significantly less ($p = 0.004$). However, elk numbers in the rest of the calving area immediately north of the well (Sections 22, 23, 26, and 27) were significantly higher ($p < 0.01$) or the same as those during the no-construction period (Figure 5-B). In the 1984 construction period, elk were observed only in the NE corner of Section 27, where use was significantly higher than expected ($p < 0.001$). See Appendix A for chi-square values.

Graphite Hollow/Rock Creek Winter Range

Elk Numbers. Numbers of elk counted during the pre-construction flights were positively correlated with depth of snow ($r^2 = 0.66$, $p = 0.008$, $n = 9$) as were numbers counted on flights during the production period ($r^2 = 0.73$, $p = 0.007$, $n = 8$). When these periods were combined, numbers counted were positively correlated ($r^2 = 0.67$, $p < 0.001$, $n = 17$; Figure 7, Table 1). During the construction period, numbers of elk counted were not correlated with snow depths ($r^2 = 0.11$, $p = .376$, $n = 9$). Similarly, numbers of elk counted on flights in the post-construction period were not correlated with snow depths ($r^2 = 0.0004$, $p = 0.97$, $n = 6$). During the construction and post-construction periods, elk numbers were highest early in winter and then declined as winter progressed. In six flights during these two periods, significantly fewer elk ($p < 0.05$) were counted than the number predicted by the linear regression developed for the pre-construction and production periods. These six flights occurred later in winter, indicating that elk left the winter range prematurely, when snow depth was still maximum.

Throughout the study there were no significant differences among the four periods in numbers of elk counted on: (1) trend counts ($p = .99$. $n = 10$), or (2) all aerial flights where more than 100 elk were counted ($p = 0.19$, $n = 26$). The average numbers of elk counted per flight during the six-year preconstruction period, the one-year construction period, the one-year post-construction period, and the four-year production period were 168, 150, 141, and 193, respectively. No correlation between elk harvest and field development was apparent. Harvest in this herd varied from 463 in 1983 to 891 in 1982. In 1989, 808 elk were harvested.

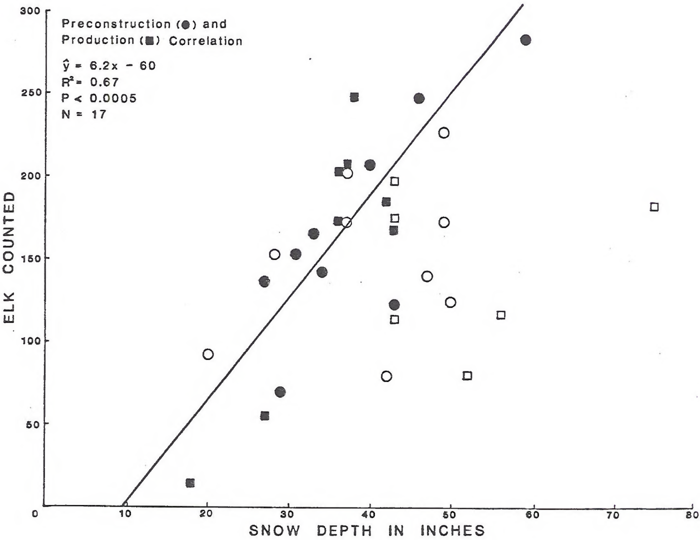

Figure 7. Correlation between snow depths and numbers of elk counted on Graphite Hollow/Rock Creek winter range, Wyoming, during pre-construction (April 1979 - May 1984) and production (November 1986 - February 1990) periods. There was no correlation between snow depths and numbers of elk counted during construction (November 1984 - May 1985) and post-construction (November 1985 - May 1986) periods (open symbols).

Elk Distribution. In the pre-construction period, elk used seven sections significantly more ($p < 0.05$) than expected. Five of these occurred in Graphite Hollow (Figure 4-A). Elk use in the Rock Creek drainage was similar to expected in three sections, and higher ($p < 0.05$) than expected in two sections. Within the mapped winter range 18 sections were used less than expected ($p < 0.05$). Mean annual snowpack during this period ranged from 54% - 127% of the 25-mean and averaged 94% (Table 3).

The well was drilled at the head of Graphite Hollow in NWNE Sec 21. During the construction period elk use increased west and southeast of the drill site. Significantly fewer elk were counted in the head of Graphite Hollow (Sections 16, 21, and 22) adjacent to the well site (Figure 4-B, Table 2). Significantly higher than expected numbers of elk were counted in Sections 26, 34, and 35:R114W, which were > 2.4 miles from the well site, and in Sections 14 and 25:T115W, which were 1.5 - 3.0 miles from the well site. Significantly more elk than expected were counted in the Rock Creek drainage (Sections 17 and 20). This area was 0.5 - 1.75 miles from the well site and insulated from it by a stand of lodgepole pine and a ridge. Mean snowpack during this period was 94% of the 25-year mean.

During the post-construction period (Figure 4-C), elk were concentrated in the central portion of the study area. Elk numbers were significantly higher than expected ($p < 0.02$) on Section 21 (the section the well was drilled in), Sections 17 and 20, (sections adjacent to the well), and Sections 24:R115W and 26:R114W (located between 1.5 - 2 miles from the well). Use of the rest of the head of Graphite Hollow (Sections 16, 22, and 27) was less than expected. Mean snowpack this year was 128% of the 25-year mean.

Distribution of elk on the GH/RC winter range during the production period was much more dispersed than during any of the other three periods with greater than expected numbers of elk counted farther to the west, south, and southeast than had been previously observed (Figure 4-D and Table 2). Observed elk numbers in the northern portion of the winter range remained low. The greatest concentrations of elk were in six central and southeastern sections of the winter range. Elk use on these sections constituted 71% of all elk seen and was significantly greater than during the pre-construction period. The south end of Lake Mountain (Section 25) was also used significantly more than in the pre-construction period.

The proportion of the elk observed in the five sections closest to the well (16, 17, 20, 21, and 22) was higher in each of the three periods following the pre-construction period, with the highest occurring in the post-construction period (Table 4). Patterns of change in numbers of elk observed within these five sections varied considerably among sections. Numbers of elk sighted in Sections 17 and 20 were significantly higher than expected during each of the periods following pre-construction while numbers in Sections 16 and 22 remained significantly lower. Within these five sections, elk use increased the most in Sections 17 and 20, and declined the most in Sections 16 and 22. Twenty two elk were

Table 3. Mean annual snow depths in inches for an SCS Snow Course Site in Snider Basin, Wyoming. Snow depths were the average of the February 1, March 1, and April 1 snow depths.

	Winter	Mean Snow Depth	% of 25 Year Mean
	1961 - 1985	48.3	
Pre-construction	1978 - 79 - 1983 - 84	45.1	94%
	1978 - 79	49.3	102%
	1979 - 80	52.7	109%
	1980 - 81	26.3	54%
	1981 - 82	61.3	127%
	1982 - 83	38.5	80%
	1983 - 84	43.0	92%
Construction	1984 - 85	45.3	94%
Post-construction	1985 - 86	61.7	128%
Production	1986 - 87 - 1989 - 90	41.4	86%
	1986 - 87	41.3	86%
	1987 - 88	41.7	86%
	1988 - 89	41.3	86%
	1989 - 90	41.0	85%

Table 4. Proportion of total elk counted, by period, in 5 sections most proximal to the GU 2-15 well site and in R115W on the GH/RC winter range.

Study Period	R114W Sections 16 & 21	R114W Sections 16, 17, 20, 21, & 22	R115W
Pre-construction 1979 - 1984	11.9%	40.7%	24.5%
Construction 1984 - 1985	5.2%	59.4%	7.6%
Post-construction 1985 - 1986	12.2%	74.9%	4.5%
Production 1987 - 1990	6.4%	45.3%	13.2%

sighted in Section 16 in the production period. This was the first time elk were observed in this section since the pre-construction period and, although these proportions of total numbers observed were significantly lower than pre-construction levels ($p < 0.001$), the return of elk to this section represents a noteworthy event. The number of elk sighted in the section east of the well (22) was significantly lower ($p < 0.001$) in all periods compared to the pre-construction numbers.

The proportion of the elk herd found in the two sections closest to the well (Sections 16 and 21) declined during the construction period (Table 4). Numbers of elk rebounded to greater than pre-construction proportions during the post-construction period, and fell to reduced levels again during the production period in Section 21. The proportion of elk found in R115W was lower during each of the three periods following pre-construction. The biggest decline occurred in the north end of Rock Creek (Section 2), while the greatest increase was on the south end of Lake Mountain (Section 25).

Radio Telemetry. Four elk were radio collared in January-April 1986 and movements between Rock Creek and Graphite Hollow winter ranges were documented. A female calf trapped on January 24, 1986 on Rock Creek was found on the east side of Graphite Hollow with 97 other elk on March 4, 1986. She moved back to Rock Creek later in March where her collar slipped off. A cow elk captured on Rock Creek moved east along Rock Creek and died about 200 yards from the bottom of the Rock Creek drainage, probably during February, 1986. Evidence of predation by a mountain lion was noted. The two remaining elk moved off the GH/RC winter range onto Packsaddle Ridge, and were west of Snider Basin in the LaBarge Creek drainage in June, 1986. They summered on the east side of Mount Coffin in the Wyoming Range (T30N:R116W:Sec 2). Neither of these elk returned to the GH/RC winter range during the winter of 1986-1987. One cow (radio frequency 172.520) moved to the south end of Porcupine Ridge along Hobble Creek (T28N:R118W:Sec 36) in Hunt Area 104. She was there, with 33 other elk, on December 12, 1986. The other cow (radio frequency 172.550) and her calf wintered in Hunt Area 94 on Big Fall Creek on the northwest side of Deadline Ridge (T28N:R118W:Sec 29). This was an area not normally used as elk winter range. If snow pack had been normal in 1986-1987, this elk would probably have moved onto the GH/RC winter range or to winter range south of LaBarge Creek.

DISCUSSION

Snider Basin Calving Area

Elk responded to drilling activities during calving season by avoiding areas near drill sites and areas visible from access routes. They also moved calves at early dates, presumable away from drilling activities (Johnson and Lockman 1980). Elk returned to areas where drilling activities occurred the year after drilling. In both 1980 and 1985 there were no activities related to field development in Snider Basin, and elk were free of disturbance during the calving season. Because these wells were not placed into production, we cannot evaluate how elk respond to field production on this calving area.

Graphite Hollow/Rock Creek Winter Range

There were no significant differences among periods in number of elk counted on the GH/RC winter range. Numbers of elk counted during trend counts have shown a slight decline, but it has not been significant ($p = 0.17$), and may be related to lower snow depths the last four years. Conversely, the average number of elk counted per aerial survey has increased from 168 during the pre-construction period, to 193 during the production period. There was no evidence that construction activities associated with the well in the head of Graphite Hollow resulted in a decrease in elk numbers on this winter range. Similarly, there was no evidence that elk harvest was affected within the herd unit.

Snow conditions in winters during the pre-construction period ranged from very mild in 1981 - 82 to very severe in 1982 - 83 (Table 3). It was assumed that elk distribution observed during this period (Figure 4-A) represented traditional preferences for habitats that provided for behavioral and physiological needs. Within the GH/RC winter range, 48% of the elk observed were found in Graphite Hollow (Sections 16, 21, 22, 27, and 34). Within the Rock Creek drainage, the highest numbers of elk were found in Section 20 (7.8%). Eighteen percent of the elk were found in Sections 2, 3, and 9 near the head of Long Hollow. These pre-construction concentration areas all contained foraging areas with adjacent cover, and were located on what were some of the most isolated portions of the winter range.

During the construction period elk moved 0.5 - 2.4 miles away from the well site. Snow depth that winter was similar to the mean observed in the pre-construction period. Areas in Rock Creek where large numbers of elk were observed (Sections 17 and 20) were as close as 0.5 mile from the well site. The use of this area by elk was probably enhanced by a mature stand of lodgepole pine and a ridge that were visual and auditory barriers between this area and the well site. The number of elk sighted in Section 34 was greater than expected during this period even though line-of-sight visibility to the well site was unobstructed from much of the area with no vegetative and little topographic hiding cover present. The fact that this section was > 2 miles from the well site may have

compensated for the lack of visual and auditory barriers and enhanced its acceptability to elk.

During the post-construction winter, there was no activity at the well site after mid-January, and snow depth was the highest reported during the study. Under these conditions elk appeared to forego some of their security preferences and moved closer to the well in exchange for shallower snow and greater forage availability. A higher proportion of the total elk counted that winter were observed using the head of Graphite Hollow (Sections 21, 22, and 26), compared to the construction period, and numbers observed in Sections 21 and 26 were significantly greater than observed in the preconstruction period. Elk numbers in Section 22 and 16 were still significantly lower than those observed during the pre-construction period. In this severe winter, elk use was concentrated in the central part of the winter range (Sections 20, 21, 22, and 26). Only 9% of all elk seen during the post-construction period were found in Section 17, in sharp contrast to the construction period when 33% of all elk counted were found that section. The decrease in use of Section 17 and increase in use of Sections 21, 22, and 26 between the construction and post-construction periods coincided with increased snow depth on this winter range and decreased activity at the well site.

Elk were more widely distributed during the production period than during any of the other periods. This widespread distribution appeared to be a function of lower snow depths, which were only 85-86% of the 25-year mean for each year, in combination with ongoing activities as the well site. The well was visited at least two times per week in this period. Elk use of the head of Graphite Hollow was greater than observed during the construction period, but less than observed during the pre-construction and post-construction periods when human activity was minimal. Observed numbers of elk were highest in the Rock Creek drainage 0.5 - 2 miles from the well site (Sections 17, 20, and 25), and in the southeast corner of the study area > 2 miles from the well site (Sections 25, 26, and 35). Seventy one percent of the elk counted during this 4-year period were in these six sections. Increased use of the south and southwest slopes of Lake Mountain was observed, indicating elk increased use of other portions of the winter range. During this period, elk use was dynamic among and within years. On the 1988 helicopter trend count 218 of 249 elk counted were in Graphite Hollow in close proximity (< 2 miles) to the well, but on later and earlier flights that winter, few elk were counted in Graphite Hollow. On the helicopter trend count in 1990, all of the elk counted were found in Section 35, T114W. Elk were observed using Section 16 during this period, the first time since the well was drilled.

Even though the well was constructed in Section 21, the percent of total sightings of elk recorded for this section changed relatively little among the pre-construction, construction, and production periods (Table 2). During the post-construction winter significantly more elk than expected were found here. The relatively small change in elk sightings from pre-construction levels may be due to several factors that combined to meet behavioral

and physiological needs of elk. These factors include a ridge which insulated part of this section from the well site activities, good security cover adjacent to and within the section, and a diverse mix of forage.

During the pre-construction period 17.8% of all wintering elk were in Section 22, between 0.5 - 1.5 miles east of the well site. During the construction, post-construction, and production periods these proportions dropped to 2.7%, 13.8%, and 3.0%, respectively. Even though Section 22 was in the opposite but same relative position to the well as Section 20, the pattern of change in elk numbers sighted in these sections was very different. As numbers of elk sighted in Section 20 increased, numbers sighted in Section 22 decreased. Numbers decreased the least in Section 22 during the deep snow winter of the post-construction period. There was good browse in this section, but security cover and visual and auditory barriers were minimal. On an elk calving range in Colorado, Brekke (1988) found that during daylight hours, elk tended to avoid line-of-sight exposure to drilling sites over distances up to 0.75 - 1 mile.

Since only diurnal surveys were conducted, it was not possible to document the extent to which elk used foraging areas under the cover of darkness. Merrill et al. (1988) report that elk in the Mount St. Helens blast zone shifted their foraging activities to the hours of darkness in response to thermoregulatory needs. Morgantini and Hudson (1979) found that elk shifted their activity patterns to the cover of darkness to avoid hunting. This raises the possibility that some areas where elk were sighted represented places where elk were secure enough to be seen during daylight hours. Nearby areas, where elk were too insecure to be found during daylight hours, may have been used at night. Most flights were conducted early in the morning or late in the afternoon to minimize this potential bias. During aerial surveys of the GH/RC winter range no evidence was found (tracks and trails in the snow), to indicate that significant nocturnal movements to feeding sites occurred.

The radio telemetry data collected during this study are of general interest, but are too limited in extent and out of sequence with the drilling and construction period to be of any real value in answering the questions posed in this study. The trapping and radio collaring operation commenced in January 1986 after the bulk of the drilling and construction activities on the GH/RC Winter Range had been completed. The data they provided were, therefore, of no use in assessing the elk displacement response to major wellfield activities. Secondly, only four animals were radio-collared and two of these were lost the first year. The two remaining elk provided information on movements between winter and summer ranges but constitute such a small sample size that no population-level inferences can be made. The fact that one of these elk was found one year later on a different winter range than the one she was captured on is not an unusual occurrence. Other radio telemetry and marking studies have shown that a certain amount of exchange between winter and summer ranges and herd units is a normal occurrence among individual elk and may be influenced by snow depth patterns during migrations.

SUMMARY

Although the areas closest to the well continue to be used by elk, the proportion of the wintering elk herd found here has been lower than pre-construction levels, except during the post-construction period when snow depths were much greater than average (Table 4). However, the proportion of the herd found within approximately 1.75 miles of the well site (Sections 16, 17, 20, 21, and 22) was higher in each of the periods compared to proportions observed in the pre-construction period. Although the proportion of the herd found within this 5-section area has increased, the distribution of animals within it varied considerably, apparently in response to the magnitude of human disturbance, depth of snow, and availability of forage and security.

Pre-construction planning and coordination among Exxon, the BLM, and WGFD were critical in siting the well in Graphite Hollow. In Exxon's original plan, the well was to have been drilled near the center of Section 21 in order to obtain the legally required spacing of wells and depletion of gas reserves within the lease units. The proposed site was visible for many miles on this winter range, and the human activities associated with servicing the well could have displaced elk away from this site. Had the well not been moved into conifer cover, out of sight from foraging areas on the winter range, it is likely the return of elk to the vicinity of the well site would have been much slower and levels of elk use would not have been as high as those we documented during the production period.

Proper siting of wells, roads, and other facilities is crucial to maintaining elk use of winter and calving ranges. In the 1970s oil and gas fields were developed on crucial elk winter ranges, by companies other than Exxon, on Pinegrove Ridge, Cretaceous Mountain, and Hogsback Ridge (Figure 2). In addition, many antennas were constructed on Hogsback Ridge, and this development now serves as a major communications link for the region. None of these activities included plans to minimize or avoid impacts to wintering elk through careful placement of facilities. These were often constructed in foraging areas instead of within conifer stands. During the 1980s, no elk were observed on Pinegrove Ridge or Hogsback Ridge winter ranges, and elk were seen during only three winters on Cretaceous Mountain. The great reduction in elk use of these winter ranges illustrates the consequences of unplanned developments.

Pre-construction planning and communications among resource management agencies and industry are necessary to avoid and minimize impacts to elk winter ranges. If impacts cannot be avoided, habitat improvements such as burning, fertilizing, pitting, and changing grazing patterns of domestic livestock may be necessary on other portions of the winter range to maintain elk populations.

CONCLUSIONS

1. No significant effect of Exxon's wellfield activities on total numbers of elk using the GH/RC winter range, or elk harvest in the Big Piney Herd was found.

2. Wellfield construction activities altered some of the traditional winter distribution patterns of elk in GH/RC.

3. Some elk returned to traditional winter ranges after intensive wellfield construction activities ceased even though less intensive activities continued (production) on GH/RC. Elk use was documented on 2/3 of all traditional use areas throughout the study, and some traditional use areas never showed depressed levels of utilization.

4. On the GH/RC winter range, the proportion of elk counted within 1.75 miles of the well site was higher during the construction, post-construction, and production periods compared to the pre-construction period. The distribution of these animals, however, changed significantly from patterns found during the pre-construction period.

5. The proportion of the GH/RC wintering elk herd found on one of the sections (16) of land closest to the well decreased significantly during the construction period and remained depressed throughout the study (1990). Some return of elk to this section was recorded during the production period. Elk numbers sighted on the other section closest to the well (21) declined significantly during the construction and production periods. During the post-construction period when activities were minimal at the well and snow depth was maximum, this section contained significantly greater numbers of elk than were seen during the pre-construction period.

6. During and following the construction period, elk expanded their use of crucial winter range in R115W into areas not previously used much or at all.

7. Although they were not specifically studied, the presence of visual and auditory barriers, increased distance from the well, proximity to security cover, depth of snow cover, and the intensity level of human activities appeared to influence elk distribution. Elk remained relatively closer to human activities when barriers or security cover were available. These factors appeared less important as distance from the disturbance increased. Under deep snow conditions elk used areas closer to human activities and appeared to forego some security to obtain use of areas with less snow cover and better forage.

8. Pre-construction planning and communications among resource management agencies and industry helped to avoid and minimize impacts to elk winter and calving ranges. Had the wells not been moved into conifer cover and road management plans adopted, it is likely the return of elk to the vicinity of the well sites would have been much slower and levels of elk use would not have been as high as those we documented following the construction period.

RECOMMENDATIONS TO MINIMIZE IMPACTS OF OIL AND GAS DEVELOPMENT ON ELK HABITAT

1. Before leases or APD's are issued, identify conflicts between oil and gas development and elk habitats, and plan solutions to problems at that time.

2. Include considerations for placement of roads and wells in the pre-construction planning. Wells and roads should be screened from foraging areas on winter range by either topographic or vegetative features. In the absence of such features wells should, if possible, be located 1.5 miles from crucial portions of the winter range.

3. If number 2 is not possible, and sometimes when it is, time construction activities to avoid periods of the year when elk will be in the area.

4. Develop road management plans, and close roads that are on elk winter ranges to all uses except field maintenance. Minimize trips on the road and, where feasible, utilize remote sensing equipment to monitor wells.

5. Identify all potential foraging sites within and adjacent to areas where development will occur. Where appropriate, implement habitat improvement projects on those areas at least one year before construction activities occur.

6. Utilize state-of-the-art drilling techniques to avoid conflicts on foraging areas of winter range. Such measures might include helicopter supported drilling activities, directional drilling, remote monitoring of completed wells, and split-season drilling.

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APPENDIX A

Chi-Square Values

Snider Basin Calving Area

TABLE A-1. Chi-square values for differences between observed and expected numbers of elk sighted on the Snider Basin Calving Area during a No-Construction Period (May 15-July 15: 1980 through 1983 and May 15-July 15: 1985 through 1987).

	T29N:R115W		
SECTION	OBS	EXP	CHI-SQUARE
1	11	33.34	28.62--
2	91	33.34	101.47++
3	107	33.34	166.23++
4	0	0.00	0.00
5	5	33.34	24.08--
6	2	33.34	29.55--
7	106	33.34	161.71++
8	15	33.34	9.89-
9	11	33.34	14.82--
10	9	33.34	17.66--
11	5	33.34	24.08--
12	23	33.34	3.01-
13	17	33.34	7.80-
14	3	33.34	27.67--
15	10	33.34	16.21--
16	28	33.34	0.73
17	2	33.34	29.55--
18	1	33.34	31.50--
19	40	33.34	1.18
20	0	0.00	0.00
21	14	33.34	11.03--
22	71	33.34	42.88++
23	62	33.34	24.62++
24	3	33.34	27.67--
25	36	33.34	0.14
26	110	33.34	180.14++
27	84	33.34	78.13++
28	28	33.34	0.73
29	2	33.34	29.55--
30	0	0.00	0.00
31	0	0.00	0.00
32	0	0.00	0.00
33	0	0.00	0.00
34	12	33.34	13.50--
35	59	33.34	19.65++
36	0	0.00	0.00
TOTAL:	967		

EXP = The number of elk that would be found in a given section if all elk sighted were distributed evenly between sections used.

OBS = Actual number of elk seen within each section.

\+ = Significantly greater than expected (+, $p<0.25$; ++, $p<0.001$).

\- = Significantly less than expected (-, $p<0.25$; --, $p<0.001$).

TABLE A-2. Chi-square values for differences between observed and expected numbers of elk sighted on the Snider Basin Calving Area during a Construction Period (May 15, - July 15, 1979).

	T29N:R115W		
SECTION	OBS	EXP	CHI-SQUARE
1	2	1.64	0.01
2	0	13.55	13.87--
3	0	15.93	16.80--
4	0	0.00	0.00
5	0	0.74	NA
6	15	0.30	NA+
7	0	15.78	16.62--
8	0	2.23	1.34-
9	0	1.64	0.80
10	18	1.34	196.72++
11	0	0.74	NA
12	0	3.43	2.56-
13	0	2.53	1.66-
14	0	0.45	NA
15	0	1.49	0.66
16	0	4.17	3.33-
17	0	0.30	NA
18	0	0.15	NA
19	0	5.96	5.22-
20	2	0.00	NA +
21	0	2.08	1.22
22	11	10.57	0.00
23	17	9.23	6.12+
24	18	0.45	NA +
25	4	5.36	0.14
26	21	16.38	1.17
27	31	12.51	28.33++
28	0	4.17	3.33-
29	0	0.30	NA
30	0	0.00	0.00
31	0	0.00	0.00
32	0	0.00	0.00
33	1	0.00	NA
34	0	1.79	0.94
35	0	8.79	8.33-
36	4	0.00	NA+
TOTAL:	144		

EXP = The number of elk that would be found in a given section if all elk sighted were distributed between sections in the same proportion as during the Pre-Construction Period.

OBS = Actual number of elk seen within each section.

\+ = Significantly greater than expected (+, $p<0.25$; ++, $p<0.001$).

\- = Significantly less than expected (-, $p<0.25$; --, $p<0.001$).

TABLE A-3. Chi-square values for differences between observed and expected numbers of elk sighted on the Snider Basin Calving Area during a Construction Period (May 15-July 15: 1984).

	T29N:R115W		
SECTION	OBS	EXP	CHI-SQUARE
1	0	0.86	NA
2	0	7.15	6.83-
3	0	8.41	8.37-
4	0	0.00	0.00
5	0	0.39	NA
6	0	0.16	NA
7	0	8.33	8.27-
8	0	1.18	0.40
9	0	0.86	NA
10	0	0.71	NA
11	0	0.39	NA
12	0	1.81	0.97
13	0	1.34	0.54
14	0	0.24	NA
15	0	0.79	NA
16	0	2.20	1.35-
17	0	0.16	NA
18	0	0.08	NA
19	0	3.14	2.32-
20	0	0.00	0.00
21	0	1.10	0.33
22	0	5.57	4.98-
23	0	4.87	4.19-
24	0	0.24	NA
25	0	2.83	1.99-
26	0	8.65	18.66--
27	76	6.60	787.68++
28	0	2.20	1.35-
29	0	0.16	NA
30	0	0.00	0.00
31	0	0.00	0.00
32	0	0.00	0.00
33	0	0.00	0.00
34	0	0.94	NA
35	0	4.64	3.93-
36	0	0.00	0.00
TOTAL:	76		

EXP = The number of elk that would be found in a given section if all elk sighted were distributed between sections in the same proportion as during the Pre-Construction Period.

OBS = Actual number of elk seen within each section.

\+ = Significantly greater than expected (+, $p<0.25$; ++, $p<0.001$).

\- = Significantly less than expected (-, $p<0.25$; --, $p<0.001$).